US LHC Accelerator Project
Progress Report, 3rd Quarter FY 2001
21 August 2001
J. Strait, Project Manager

I. Summary

Good technical progress continues across the Project. The prototype quadrupole was tested at 2K and met all requirements for the first thermal cycle. All five D1 dipole cold masses have been completed. Design of the feedboxes is over 70% complete, and large IR absorber shielding parts are starting to arrive from vendors.

The project has an favorable cost variance of $0.8M (+1%), and a schedule variance of -$3.2M (-5%), $6.6M and $1.9M better than last quarter respectively. The favorable changes were due to rebaselining of the BNL and FNAL programs, resulting in an increased BAC. Rebaselining is also process for the LBNL program, but the final numbers were not available in time to change their baseline for this report. The new EAC includes the new baseline numbers except for the feedboxes, which is undergoing intense review by the Project Office. Based on an earned value of $66.7M, the project is 65% complete. The EAC remains at $103.5M.

Production of quadrupoles has begun. A production readiness review for the cold mass was conducted on 20 June. The collared coil for the first production unit, MQXB01, has been completed. The prototype was tested at 2K and performed as expected; it reached the required 230T/m in ten quenches, the field errors are within limits, and quench protection was good.

Dipole magnet production continues. All five D1 dipoles cold masses were completed and are being prepared for assembly into cryostats and subsequent testing. The first D2 cold mass is essentially complete, as are the collared coils for the second D2. CERN is changing the configuration at LHC Insertion Region 4, which will reduce the number of D3 and D4 magnets. It will also simplify the interconnects although this will require some redesign of the D4 electro-mechanical end connections. Purchase orders for parts no longer needed have been canceled.

The first of the 3-D models of the feedbox is complete except for final modifications of the beam screen cooling circuit. The other models and 2-D fabrication drawings will be generated from this model. The overall design effort is estimated to be 73% complete. Detailed design of the IR absorbers is essentially complete. Major purchase orders have been placed, with copper absorbers and steel shielding for the TAN received.

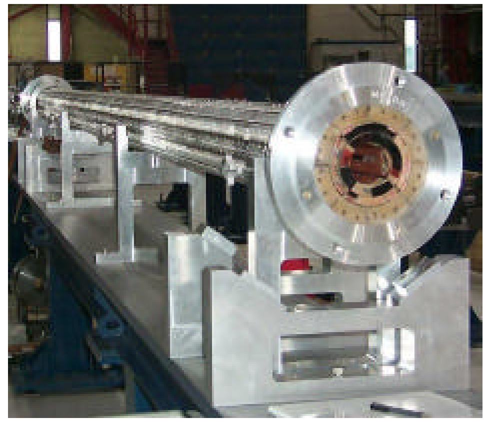
Cable testing is continuing but still limited by the rate at which production samples are being received.

Accelerator physics effort has centered on the optics changes at IR4, electron cloud simulations, impedance calculations for the TAN beam chamber, beam-beam effects, optics for 2nd generation final focus systems, and energy deposition in the insertions.

II. Technical Status

1.1.1 IR quadrupoles

The prototype performed well during testing. The magnet reached 230T/m in ten quenches, harmonics were good and quench protection was as expected. Based on the good performance of the first prototype, it has been decided to cancel the second prototype and go straight to production.



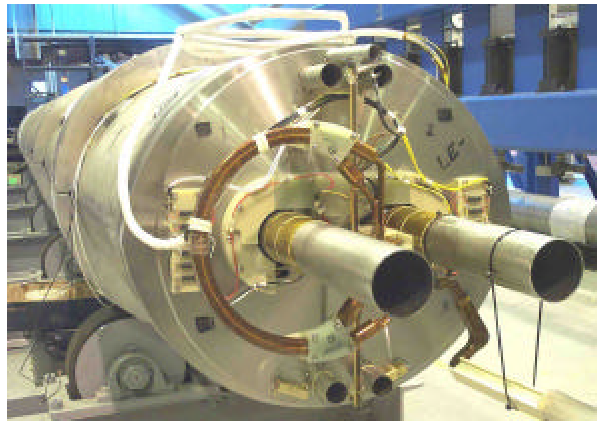
The collared coil for the first production magnet, MQXB01, was completed (see figure). Cold mass drawings are essentially complete, and specifications and travelers for the MQXB cold mass are 90% complete. Sixty-nine inner and 61 outer layer cable unit lengths, out of 90 required, have been successfully produced by NEEW. Wire for the remaining outer cable exists, and inner wire is on order. The I_c exceeds the minimum specification for all cables measured so far. The vacuum vessel order has been issued and delivery of the first vessel, a Q2, is scheduled for December 15, 2001. Design continues on the Q1-Q2 and Q2-Q3 interconnects. A mockup has been built, which includes the bus, expansion joint, splices and correction coils, to prove the viability of the design. Work on the main bus is nearing completion with small bus to follow.

Production cryostat designs are being made by modifying details from the prototype assembly to reflect the length variations with production magnet type and design modifications based on the prototype experience. The detailed location of the beam position monitors on the production magnets is still uncertain. Additionally, the CERN vacuum group still needs to define the requirements of the beam tube liners and absorbers. These are not immediate impediments but will preclude completion of production drawings until these are resolved. The peak radiation load at the location of the cold mass slide (which contains Teflon) is an area of concern. The latest dose studies indicate that the dose at the support locations can be reduced to an acceptable level by adding shielding between the TAS and the inner surface of the experimental shielding.

1.1.2 Interaction Region Dipoles / 1.2.1. RF Region Dipoles

There was a significant impact on the D3 and D4 magnet programs due to a change in the layout around IP4. CERN decided to move the RF cavities to IP4 to remedy a physical interference with the QRL. The possibility of installing an experiment at IP4 is lost in exchange for avoiding a complicated arrangement of the QRL in this region. This change has allowed a new layout of IR4, which reduces the number of dipoles and quads in this region. The wide aperture spacing quadrupoles, that CERN had hoped that BNL could build, are no longer required. Single D3 and D4 magnets will replace the D3a-D3b and D4a-D4b magnet combinations respectively. The D4 magnet is moved to the opposite side of the DFBA, which eliminates the need to for the D4 to carry the busses for the main arc magnets, and allows it to be operated at 4.5 K. D4 is now identical to D2 except for the beam aperture spacing which will be 194 mm (the same as the former D4b magnet). Three each of D3 and D4, including spares, will be made. The required delivery dates for the magnets do not change. Shop orders and purchase orders were revised to reflect the lesser numbers of D3 and D4 magnets being built. The total number of 36 inch diameter cryostats is reduced from 21 to 15.

D1 and D2 magnet production continues. The lead end of the first D1 magnet to be prepared for assembly into its cryostat, is shown in the left hand figure below. All five D1 magnets were successfully yoke-collared, although four of the five magnets had shorts and had to be disassembled, repaired and reassembled. Shell welding, end plate welding, cradle welding, electro-mechanical assembly, heat exchanger assembly, end volume welding and cold mass



survey are complete on all five magnets. All five D1 cold masses are waiting for parts to begin phase separator installation. The D1 magnet assembly drawing is in checking. D1 magnet Post-Testing/Prep to Ship Assembly is in checking. D1 non-lead end interconnect design has started. All five D1 vacuum vessels have been received.

The cradle welding assembly for the first D2 magnet is complete and the magnet is ready for initial survey. The electromechanical assembly of this magnet is shown in the right hand figure above. Collar assembly is complete on the second D2 magnet. Installation of the Cryostat Insertion Fixture has started. D2 Magnet Assembly and mini-QQS designs are complete. Welded shell samples from the first production D2 magnet were sent out for impact testing at 4K and tensile testing at 68 F. The vacuum vessel order for D2/D3/D4 was placed and the vendor is ordering material. A purchase order was released for the balance of the D2 level probes. Conceptual design of the magnet shipping fixture has started. Cable wrapping is complete, except for the five unit lengths of additional cable to be made from Oxford wire.

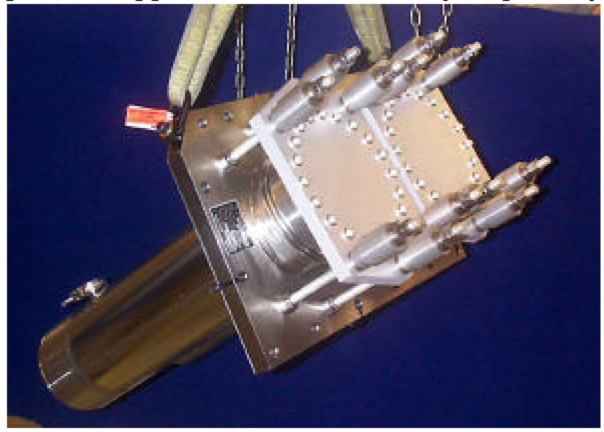
Design work continues on the instrumentation feed through system (IFS). To make cold mass insertion possible, there will be a flex hose section beyond the thermal station at the heat shield up to the cup at the cryostat wall. This allows that part of the IFS outside the heat shield to be temporarily relocated in front of the cold mass during insertion. Agreement from CERN on this approach will be sought. CERN will check the design for thermo-acoustic oscillations with the tube fill factor we have, including the complication of the flex hose at the end.

1.1.3 Cryogenic lead and feed boxes

The new HTS lead model from Pirelli is now in the 3-D DFBX model and has been used to establish the locations of the lower ends of the current leads; adding a level of detail that was previously missing. Solid models for the 120 A and 600 A current leads have been updated with the lower ends also added to the model. Changes and updates were completed on the thermal shield models and drawings. The 3-D model of the identical DFBXC and DFBXG feed boxes is complete except for final modifications to the beam screen cooling circuits. A ProEngineer product structure of the DFBX is being developed to allow easy generation of the other models and the detail drawings of the individual parts. Overall the design effort is 73% complete.

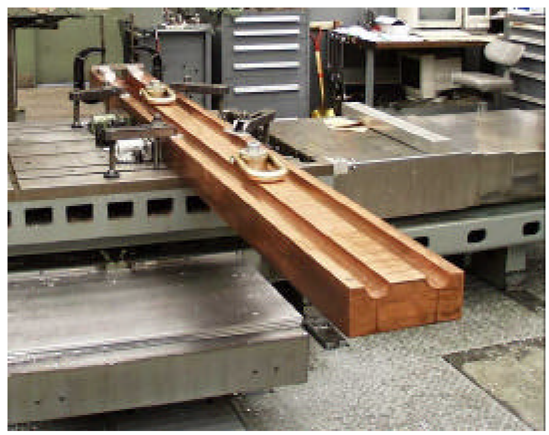
The helium chamber mock-up, including ribs to simulated the interior and side plates to simulate the access conditions, was completed. The mock-up will be used to route bus cabling for the HTS and low current leads. Testing of the Mark III lambda plate, with the conductor glued into the G-10 plug with Stycast, was completed and revealed some leak problems. The next test will use very low viscosity hardener and a multiple step epoxy process.

Pirelli failed to meet their June 28 delivery date for the first HTS and it is now scheduled to arrive at CERN at the end of July for testing. The problem appears to be late delivery of parts by their subcontractors. There is no problem with the overall DFBX schedule as long as the slip does not continue much longer. A new testing time will have to be negotiated with CERN. Fabrication of parts for the HTS lead testing at CERN is nearing completion. In a similar fashion we are in the final stages of preparing two test chambers that will be used by Pirelli to perform verification tests on the 7.5kA leads they are manufacturing. (See figures at right.)



1.1.4 IR absorbers

Good progress was made in procurements; 14 of 75 TAN items and 3 of 45 TAS items are on order and more are in the RFQ stage. The large steel shield pieces for the TAN have been received (see figure below left). The inner copper absorbers for the TAS and TAN have been received and the copper beam tube channels were machined (see figure below right). The TAS vacuum beam tube design interfaces are still evolving at CERN, causing delays in order placement. This will be discussed during a visit by LBNL personnel to CERN 13-17 August.



Brazing of the TAN vacuum tube, rather than e-beam welding, is being reconsidered, based on the recommendation of SLAC. The SLAC e-beam facility is committed to beam tube production for SPEAR for the next 50 weeks. Additionally there is technical concern that the e-beam process would leave material spatter with a full penetration weld or a gap, resulting in a virtual leak, if partial penetration welds were used. Brazing would require a high strength material such as Glidcop in order to avoid annealing at brazing temperatures. There has been a lot of Glidcop brazing work at SLAC and LBNL, so confidence in the material change is high.

A Baseline Change Request (BCR 24) was approved to allow a minimal beam test of luminosity instrumentation at CERN in September 2001 to demonstrate pulse width less than 25 ns. Design improvements since the beam test last year include better impedance matching of the front-end preamplifier to the chamber, separation of the preamplifier and the shaper onto two different circuit boards to help in the coupling between two different stages. A method of bench testing the ionization chamber to simulate the proton shower has been devised, which will allow a reasonably realistic test of the combined bandwidth of the ionization chamber and electronics prior to shipment to CERN. Orders have been placed for approximately 80% of the purchases needed and 95% of the drawings needed for modification of the ionization chamber have been provided to the LBNL shops.

1.1.5 IR System Design

The annual collaboration meeting between FNAL, CERN and KEK was held at KEK in April, which included discussions on mechanical and electrical integration of the inner triplet system. The KEK meeting was very useful in confirming the interface requirements on the KEK cold mass to be delivered to Fermilab. The meeting included a visit to Toshiba, who is making the full-length quadrupoles for KEK. Successful trial insertions were made into the prototype of models of the main and corrector bus assemblies and of a beam tube segment. Based on the test, the tray which houses the main bus needs to be widened to better fit the KEK bus slot.

The overall quench protection and electrical layout of the inner triplet as well as the bus work and instrumentation of the KEK MQXA were addressed. The scheme for powering the inner triplet is now being codified into the official CERN powering schematics. The use of a bypass thyristor and a system ground at one of the Q2 terminals effectively decouples the protection of the Fermilab MQXB and KEK MQXA magnets. Extensive studies and computer simulations during the model magnet program have shown that the peak temperatures will be less than 400 K and the voltages to ground should not exceed 400 V under normal operating conditions.

Instrumentation wires will be connected at each interconnect in the inner triplet. We are considering a connector rather than a solder splice, which allows faster installation in the tunnel with no worry about mis-wiring. A type of connector that has been used with high reliability in both BNL and FNAL magnet test facilities for more than 10 years is proposed. The plastic parts are composed primarily of diallyl phthalate, which is reported to have excellent radiation hardness properties. More research is needed to confirm that this material can withstand the radiation levels expected in the inner triplet interconnects.

1.3.1 Superconductor Testing

Cable test activity consisted of 24 days of testing at 4.3K for the quarter, with 98 cable tests performed on LHC production cable, 12 for HGQ cable and 4 for reference cable. The total number of cable tests per month appears in the table below. Some LHC cable samples were tested in perpendicular field with both normal and reverse polarities to determine the difference in I_c between the thick and thin-edge of the keystoned cable.

1.3.2 Superconducting Cable Production Support

CERN is ordering two additional cable measuring machines and two additional spare measuring heads from Humboldt Instruments in San Leandro, CA. Delivery to CERN is scheduled for early next year. LBNL staff is assisting CERN in monitoring the procurement.

1.4 Accelerator Physics

The impact of halving the number of separation dipoles D3 and D4 in IR4 to take advantage of the free space generated by moving the RF cavities was studied. The results showing that using only a single D3 and D4 on each side of the IP is feasible were forwarded to CERN, who accepted the proposal and have completed the new layout of IR4.

CABLE TEST EFT's					Updated: 07/10/01			
EFT= "Equivalent 4.2K Test"	No. days @4.2K	Non-productive days	Fraction of cryo for LHC	# of LHC EFT's	# of HGQ EFT's	# of RF-dipole EFT's	# of Reference Cable Test	TOTAL
Total to Date	152	7		424	64	40		538
Oct-00	11	0	0.367	30	4	4	0	38
Nov-00	8	2	0.364	20	0	0	6	26
Dec-00	8	1	0.438	20	0	0	0	20
Jan-01	11	0	0.393	30	8	0	0	38
Feb-01	6	0	0.333	12	12	0	0	24
Mar-01	7	0	0.368	27	0	0	0	27
Apr-01	6	0	0.4	15	8	0	0	23
May-01	9	0	0.474	49	4	0	0	53
Jun-01	9	0	0.476	29	4	0	4	37
Jul-01	0	0	0	0	0	0	0	0
Aug-01	0	0	0	0	0	0	0	0
Sep-01	0	0	0	0	0	0	0	0
Total, FY'01	75	3	0.401	232	36	4	10	282
Total FY'99	31	3		65	10	8		83
Total FY'00	46	1		127	18	28		173
EFT Budget				3430	84	40	48	3602

A detailed study of strong-strong beam-beam interactions in hadron colliders was recently completed submitted for publication. This study was of dynamics in 1 degree of freedom, and it will next be extended to study 2 degrees of freedom. A beam-beam workshop was held at FNAL 25-27 June. The focus was on new developments in the understanding of beam-beam phenomena in circular colliders, primarily hadron colliders. Topics addressed include long-range interactions, beam-beam compensation and coherent effects.

Vigorous work continues on the electron cloud effect (ECE). Results from LBNL's ECE code have been compared with measurements in the APS, PSR and PEP-II. The simulations for the APS and PSR show good agreement with dedicated electron measurements, strengthening our confidence in the simulation code applied to LHC. The new improved version of the ECE simulation code has been applied to simulation of the power deposition in the LHC arcs, both in a dipole magnet and a field-free region. Four models of the secondary emission yield were tested. In the first case, which has only true secondary electrons (i.e., no elastically-backscattered or re-diffused incident electrons). the results are in very good agreement with CERN simulations. The remaining 3 models contain various degrees of added details pertaining to the backscattered and re-diffused electrons. The results of these are under discussion with CERN.

MAFIA calculations of TAN vacuum chamber impedance with rectangular geometry have reproduced the trapped mode results obtained at Frascati. No trapped modes exist when the correct cylindrical geometry is used. Still to be calculated are the scaling of impedance and trapped mode behavior with the taper angle of the TAN transition vacuum chamber.

III. Financial Status

Cost and Schedule Performance

The current performance data at WBS level 2 are summarized in Table I, and the changes since the last quarter for the program as a whole are contained in Table II. The CPR (Format 1, by WBS, and Format 2, by laboratory) for the 3rd quarter of FY 2001 (the current period columns of the report represent three months of data) and three trend charts (cumulative performance, cost/schedule variance, and bull's-eye) are included as attachments. The favorable changes to the cost and schedule performances were due to rebaselining efforts at BNL and FNAL which resulted in an increased BAC. Rebaselining is also occurring at LBNL, but the final numbers were not available in time to change their baseline for this report. However, we were able to adjust their EAC to reflect new baseline numbers except for the DFBX (WBS 1.1.3), which is undergoing intense review by the Project Office.

Table I. Current cost performance data.

	Cumulative Costs to Date					Costs at Completion		
WBS	BCWS	BCWP	ACWP	SV	CV	BAC	EAC	VAC
1.1 IR Region	40,503	37,676	37,496	-2,827	+180	55,107	55,672	-565
1.2 RF Region	10,916	10,706	9,491	-210	+1,215	17,148	17,148	0
1.3 SC Wire/Cable	7,377	7,264	7,136	-113	+128	13,326	13,218	+108
1.4 Accel Physics	2,664	2,664	2,694	0	-30	4,077	3,660	+417
1.5 Project Mgt	8,391	8,391	9,117	0	-726	13,538	13,765	-227
Contingency						6,804	6,537	-267
Total	69,851	66,700	65,934	-3,151	+766	110,000	110,000	0*

*Note: Total VAC is equal to sum of WBS VACs minus the Contingency VAC.

Table II. Cost performance changes since the previous report.

	Last Quarter	This Quarter
Total Project Cost (TPC)	110,000K	110,000K
Budget At Completion (BAC)	96,655K	103,196K
Cum Budget to Date (BCWS)	62,134K	69,851K
Earned Value (BCWP)	57,078K	66,700K
Actual cost & commitments (ACWP)	62,697K	65,934K
Budgeted Cost of Work Remaining (BCWR)	39,577K	36,496K
Schedule Variance (SV)	-5,056K (-8%)	-3,151K (-5%)
Cost Variance (CV)	-5,619K (-10%)	+766K (+1%)
Estimate At Completion (EAC)	103,514K	103,463K
Contingency (TPC – EAC)	6,486K	6,537K
Contingency as a % of BCWR	16.4%	17.9%

At Brookhaven, the +$239K cumulative favorable cost variance is primarily due to a +$217K variance in overheads. The lump sum credit for the annual reduction in space charges occurred after the "as of" date (Dec 31, 2000) set for the rebaseline. There will be another lump sum distribution in the next quarter due to BNL's space charge increasing, thereby increasing the value of the lump sum distribution. There will be a positive variance in overheads at the end of FY01 because no credit was taken in the "to go" baseline for the actual charges prior to Dec 31. Direct costs at BNL are slightly favorable, but are a mix of unfavorable material variances being offset by favorable labor, central shops, and special procurement variances. It is too soon to tell whether the positive or the negative variances will dominate. BNL has been reminded that they need to be proactive in controlling costs. BNL's -$533K schedule variance primarily resides in D2 production (-$154K), RF magnet EDIA (-$99K), Superconducting Cable Testing (-$89K), and the overheads related to these items (-$105K). D2 production is late because D1 was late (thanks to having to re-collar four of the five D1s), RF magnet EDIA was held up to complete IR magnet design, and cable samples have not arrived from CERN at the rate in the schedule baseline. The magnet production schedule will be revised due to a reduction in the RF magnet quantities as a result of an LHC lattice change.

At Fermilab, the "as of" date for the rebaselining effort was May 31, 2001. Therefore, the cumulative variances shown (+$161K for schedule and +$281K for cost) are really the June variances and could stem from a mismatch of taking credit for orders before the commitments went into the accounting system. More months of data are required before meaningful analysis can take place.

Berkeley's favorable cost variance of +$239K is still dominated by the favorable price achieved on the HTS leads for the DFBX. However, during the rebaselining effort, LBNL developed an ETC for the DFBX that indicated the underrun would turn into a significant overrun during production. The fact that the projected cost increases are in the future gives the Project Office an opportunity to examine alternative approaches, which it is doing. 80% of LBNL's negative schedule variance of -$2,779K is in the DFBX with the remainder in Absorbers. A BCR for the Absorbers has been approved which will result in its schedule variance going to zero.

Estimate At Completion (EAC)

The EAC has not changed significantly from last quarter. However, it does not contain the DFBX ETC mentioned above. The Project Office intends to finish its examination of alternative approaches before accepting a new EAC for the DFBX.

Baseline Change Requests

BCRs 24 (LBNL absorber luminosity instrumentation), 25 (BNL magnet, accelerator physics, and project management rebaseline), 26 (BNL superconducting test rebaseline), were presented to the Steering Committee this quarter and recommended for approval. BCRs 27 (LBNL absorber rebaseline), 29 (LBNL cable, accelerator physics, and project management rebaseline, 30 (FNAL magnet, accelerator physics, and project management rebaseline), and 31 (FNAL horizontal test facility modifications) were presented to the Steering Committee on 25 July and recommended for approval. BCR 28 (LBNL DFBX rebaseline), also presented on 25 July, was not recommended for approval and sent back to LBNL for further review. BCRs 24, 25, 26, 30, and 31 have been incorporated into the June 2001 baseline. BCRs 27 and 29 will be incorporated into the July 2001 baseline.

Funding

Excess funds at LBNL were transferred to BNL and FNAL to finish out FY01. However, to preclude any possibility of a funding deficit at BNL or FNAL, DOE, at the Project Office's request, is transferring some unused funds from the CERN direct pay account to FNAL ($500K) and BNL ($200K). This $700K transfer will be considered an advance on FY02 funds. However, FY02 could result in a serious funding shortfall. The rebaselining effort completed so far (which does not yet include any DFBX impacts) indicates that FY02 funding may fall almost

$4M short of requirements (see the US LHC Financial Tracking Data chart, attached). Although negative schedule variances may mitigate this somewhat, a significant shortfall is virtually certain. If CERN direct payments continue to lag at their present pace (close to $10M behind so far), the shortfall could be covered by an adjustment of the Accelerator and CERN Direct Pay funding profiles without adjusting the bottom line profiles.

IV. Milestone Status

The status of level 2 milestones is displayed in schedule format in an attachment. Table IV lists all level 1 and 2 milestones from the beginning of the Project through FY2002, and Table V shows the level 3 milestones affected during the quarter. Changes are highlighted in bold print. Actual dates are shown for completed milestones and forecast dates are given for milestones that have slipped out of the quarter or, due to pending changes in the program schedule, are expected to be achieved at times substantially different from the baseline dates. Level 2 milestones for deliveries to CERN are based on out-dated schedules, both ours and CERN's, and will be revised for subsequent reports. Level 1 and 2 milestones are displayed graphically in an attachment. The forecast dates have been entered for milestones with baseline dates through the end of FY2002.

Table IV. Level 1 and 2 U.S. LHC Accelerator Baseline Milestones through FY2002.

WBS Identifiers	Milestone Description	Baseline Date	Forecast(F) or Actual(A)
Project	Decision as to whether or not the US Project includes RF region quadrupoles	1 Jul 01	**20 Jun 01 (A)**
Int Region	Begin 1st inner triplet quadrupole model magnet	1 Jul 97	1 Jul 97 (A)
Int Region	Complete inner triplet quadrupole model magnet program phase 1	1 Dec 99	28 Sep 99 (A)
Int Region	Complete inner triplet quadrupole model magnet program phase 2	1 Mar 00	17 Mar 00 (A)
Int Region	Place purchase order for HTS power leads	1 Feb 00	30 Aug 00 (A)
Int Region	Begin absorber fabrication	1 Nov 00	30 Oct 00 (A)
Int Region	Complete inner triplet quadrupole prototype program	1 Oct 01	**1 Sep 01 (F)**
Int Region	Begin IR beam separation dipole production assembly	1 Oct 00	25 Jul 00 (A)
Int Region	Begin inner triplet feedbox fabrication	1 Mar 01	**15 Nov 01 (F)**
Int Region	Begin inner triplet quadrupole production assembly	1 Nov 01	**1 May 01 (A)**
Int Region	Complete 1st inner triplet quadrupole magnet	1 Sep 02	1 Sep 02 (F)
Int Region	Delivery of D2 for IR8 left	1 Apr 02	1 Apr 02 (F)
Int Region	Complete inner triplet feedbox fabrication	1 May 02	**1 Nov 03 (F)**
RF Region	Begin assembly of 1st dipole model magnet	1 Sep 99	10 Jun 99 (A)
RF Region	Complete dipole model magnet program	1 Aug 00	8 Nov 00 (A)
RF Region	Begin RF region dipole production assembly	1 Jan 02	1 Jan 02 (F)
RF Region	Delivery of D3, D4 for IR4 right	1 Jan 02	1 May 03 (F)
SC Cable	All cable prod. support equipment delivered to CERN	1 Sep 99	28 May 99 (A)
SC Cable	Complete SC testing facility upgrades	1 Jun 99	30 Sep 99 (A)

Table V. Changes to Level 3 U.S. LHC Accelerator Baseline Milestones during current quarter.

WBS Identifiers	Milestone Description	Baseline Date	Forecast(F) or Actual(A)
Int Region	MQXB to LQX Cryostat Interface Specification approved	15 Oct 00	**11 Jul 01 (F)**
Int Region	MQXA to LQX Cryostat Interface Specification approved	1 Jan 01	**1 Dec 01 (F)**
Int Region	MQXB Functional Specification approved	15 Oct 00	**23 Apr 01 (A)**
Int Region	LQX Functional Specification approved	1 Dec 00	**1 Jan 02 (F)**
Int Region	TAS2/3 Functional Specification approved	1 Dec 00	1 Jan 02 (F)
Int Region	Inner Triplet Corrector Interface Specifications approved	15 Oct 00	**1 Dec 01 (F)**
Int Region	LQX Tunnel Installation and Alignment Specification Approved	1 Jun 01	**1 Jan 02 (F)**
Int Region	LQX (Q3) to DFBX Interface Specification approved	15 Oct 00	**13Jul 01 (F)**
Int Region	LQX to Cold Bore Tube Interface Specification approved	1 Jan 01	**1 Nov 01 (F)**
Int Region	LQX to BPM Interface Specification Approved	1 Apr 01	**1 Jan 02 (F)**
Int Region	LQX to LQX Interface Specification Approved	1 Jun 01	**1 Jan 02 (F)**
Int Region	LQX to Warm Beam Vacuum Interface Specification Approved	1 Jun 01	**1 Jan 02 (F)**
Int Region	Begin Assembly of first MQXB	15 Jul 01	**1 May 01 (A)**
Int Region	MQX Cryostat Engineering Design Review	1 Nov 00	**7 May 01 (A)**
Int Region	D1 Production Complete	19 Jun 01	**19 Nov 01 (F)**
Int Region	DFBX Interface Specifications approved	1 Jul 99	**1 Oct 01 (F)**
Int Region	DFBX Engineering Design Review	1 Jul 00	**10 May 01 (A)**
Int Region	DFBX Production Readiness Review	1 Nov 00	**15 Nov 01 (F)**
Int Region	TAN and TAS Production Readiness Review complete	1 Jul 00	**31 Jan 01 (A)**
Int Region	Begin Fabrication of First DFBX	1 Dec 00	**15 Nov 01 (F)**
RF Region	D4 Interface Specification Approved	1 May 01	**10 Oct 01 (F)**
RF Region	D4 Engineering Design Review Complete	15 Apr 01	**28 Jun 01 (A)**
RF Region	D4 Production Readiness Review Complete	15 Jun 01	**28 Jun 01 (A)**

COST PERFORMANCE REPORT
FORMAT 1 - WORK BREAKDOWN STRUCTURE

DOLLARS IN Thousands

1. CONTRACTOR	2. CONTRACT	3. PROGRAM	4. REPORT PERIOD
a. NAME US LHC Accelerator Project Office	a. NAME US LHC by Qtr	a. NAME US LHC Accelerator Project	a. FROM *(YYMMDD)* 010401
b. LOCATION *(Address and ZIP Code)* MS 343 PO Box 500 Batavia, IL 60510	b. NUMBER 1 c. TYPE FFP d. SHARE RATIO 100/0 100/0	b. PHASE *(X one)* x RDT&E x PRODUCTION	b. TO *(YYMMDD)* 010630

5. CONTRACT DATA

a. QUANTITY	b. NEGOTIATED COST	c. EST. COST AUTH UNPRICED WORK	d. TARGET PROFIT/ FEE	e. TARGET PRICE	f. ESTIMATED PRICE	g. CONTRACT CEILING	h. ESTIMATED CONTRACT CEILING
0/0/0	$103,195.7	$0.0	$0.0 / 0.0%	$103,195.7	$103,463.0	$110,000.0	$110,000.0

6. ESTIMATED COST AT COMPLETION

	MANAGEMENT ESTIMATE AT COMPLETION (1)	CONTRACT BUDGET BASE (2)	VARIANCE (3)
a. BEST CASE	$103,463.0		
b. WORST CASE	$103,463.0		
c. MOST LIKELY	$103,463.0	$103,195.7	-$267.3

7. AUTHORIZED CONTRACTOR REPRESENTATIVE

a. NAME *(Last, First, Middle Initial)*	b. TITLE
Jim Strait	Project Manager
c. SIGNATURE	d. DATE SIGNED *(YYMMDD)* 010801

8. PERFORMANCE DATA

ITEM (1)		CURRENT PERIOD: BUDGETED COST WORK SCHEDULED (2)	BUDGETED COST WORK PERFORMED (3)	ACTUAL COST WORK PERFORMED (4)	VARIANCE SCHEDULE (5)	VARIANCE COST (6)	CUMULATIVE TO DATE: BUDGETED COST WORK SCHEDULED (7)	BUDGETED COST WORK PERFORMED (8)	ACTUAL COST WORK PERFORMED (9)	VARIANCE SCHEDULE (10)	VARIANCE COST (11)	REPROGRAMMING ADJUSTMENTS: COST VARIANCE (12)	BUDGET (13)	AT COMPLETION: BUDGETED (14)	ESTIMATED (15)	VARIANCE (16)
a. WORK BREAKDOWN STRUCTURE ELEMENT																
1.1 - Interaction Reg	2	5,538.7	5,744.4	1,882.6	205.7	3,861.8	40,503.1	37,675.7	37,496.2	-2,827.4	179.5			55,107.0	55,671.4	-564.4
1.1.1 - Quadrupoles	3	3,696.7	4,008.2	979.5	311.5	3,028.6	25,429.3	25,572.5	25,568.4	143.2	4.1			34,515.6	34,623.0	-107.4
1.1.2 - Dipoles	3	1,025.5	1,640.5	634.8	615.0	1,005.7	6,241.9	6,032.2	6,354.4	-209.6	-322.1			8,863.6	8,863.5	0.1
1.1.3 - Cryo Feedboxes	3	598.8	82.6	145.4	-516.3	-62.8	5,210.4	2,939.7	2,417.8	-2,270.7	521.9			6,728.3	6,281.5	446.8
1.1.4 - Absorbers	3	262.1	57.6	82.9	-204.5	-25.2	2,920.8	2,430.5	2,467.3	-490.2	-36.8			4,074.3	4,978.3	-904.0
1.1.5 - System Design	3	-44.4	-44.4	40.0	0.0	-84.5	700.8	700.8	688.4	0.0	12.5			925.1	925.1	0.00
1.2 - RF Region	2	533.0	2,042.9	341.7	1,509.8	1,701.1	10,916.3	10,706.1	9,491.0	-210.2	1,215.1			17,148.2	17,148.3	-0.1
1.2.1 - Dipoles	3	533.0	2,042.9	341.7	1,509.8	1,701.1	10,916.3	10,706.1	9,491.0	-210.2	1,215.1			17,148.2	17,148.3	-0.1
1.3 - SC Wire & Cable	2	833.7	1,023.4	306.3	189.7	717.2	7,377.3	7,264.3	7,136.4	-113.0	127.9			13,326.1	13,218.1	108.0
1.3.1 - SC Testing	3	811.2	999.5	299.2	188.3	700.3	6,299.4	6,186.6	6,076.3	-112.8	110.3			12,192.1	12,192.1	-0.00
1.3.2 - Cable Prod S'pt	3	22.5	24.0	7.0	1.4	16.9	1,077.9	1,077.7	1,060.1	-0.2	17.6			1,134.0	1,026.0	108.0
1.4 - Accel Physics	2	131.2	131.2	212.2	0.0	-81.1	2,663.8	2,663.8	2,694.1	0.0	-30.3			4,076.6	3,660.1	416.5
1.5 - Project Mgt	2	680.4	680.4	494.1	0.0	186.3	8,390.5	8,390.5	9,116.6	0.0	-726.1			13,537.8	13,765.1	-227.3
OV - OVERHEAD	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0

Unclassified

CLASSIFICATION *(When filled in)*

COST PERFORMANCE REPORT
FORMAT 1 - WORK BREAKDOWN STRUCTURE

DOLLARS IN Thousands

8. PERFORMANCE DATA

ITEM	CURRENT PERIOD					CUMULATIVE TO DATE					REPROGRAMMING ADJUSTMENTS		AT COMPLETION		
	BUDGETED COST		ACTUAL	VARIANCE		BUDGETED COST		ACTUAL	VARIANCE						
	WORK SCHEDULED	WORK PERFORMED	COST WORK PERFORMED	SCHEDULE	COST	WORK SCHEDULED	WORK PERFORMED	COST WORK PERFORMED	SCHEDULE	COST	COST VARIANCE	BUDGET	BUDGETED	ESTIMATED	VARIANCE
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
a. WORK BREAKDOWN STRUCTURE ELEMENT															
b. COST OF MONEY 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0
c. GENERAL & ADMINISTRATIVE 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0
d. UNDISTRIBUTED BUDGET 2													0.0	0.0	0.0
e. SUBTOTAL *(Performance Measurement Baseline)*	7,717.1	9,622.3	3,236.9	1,905.2	6,385.4	69,851.0	66,700.4	65,934.3	-3,150.5	766.1	0.0	0.0	103,195.7	103,463.0	-267.3
f. MANAGEMENT RESERVE 2												0.0	0.0		
g. TOTAL	7,717.1	9,622.3	3,236.9	1,905.2	6,385.4	69,851.0	66,700.4	65,934.3	-3,150.5	766.1	0.0	0.0	103,195.7		
9. RECONCILIATION TO CONTRACT BUDGET BASE															
a. VARIANCE ADJUSTMENT									0.0	0.0					
b. TOTAL CONTRACT VARIANCE									-3,150.5	766.1			103,195.7	103,463.0	-267.3

Unclassified

CLASSIFICATION *(When filled in)*

COST PERFORMANCE REPORT
FORMAT 2 - ORGANIZATIONAL CATEGORIES

DOLLARS IN Thousands

1. CONTRACTOR
a. NAME US LHC Accelerator Project Office
b. LOCATION *(Address and ZIP Code)*
MS 343
PO Box 500
Batavia, IL 60510

2. CONTRACT
a. NAME US LHC by Qtr
b. NUMBER 1
c. TYPE FFP
d. SHARE RATIO 100/0 100/0

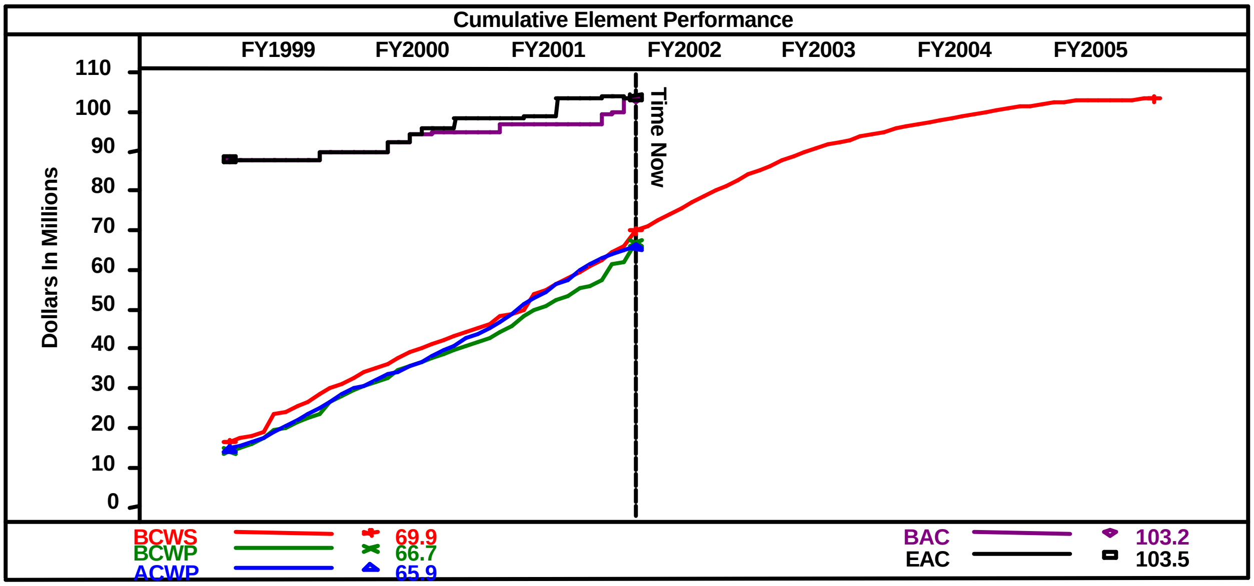
3. PROGRAM
a. NAME US LHC Accelerator Project
b. PHASE *(X one)* x **RDT&E** x **PRODUCTION**

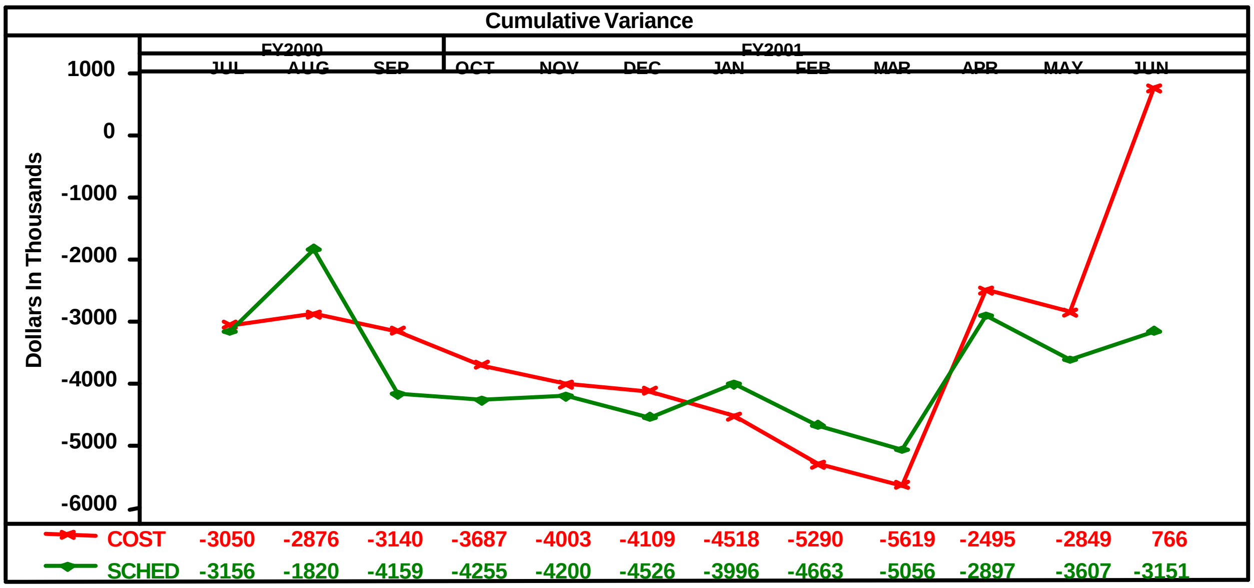
4. REPORT PERIOD
a. FROM *(YYMMDD)* 010401
b. TO *(YYMMDD)* 010630

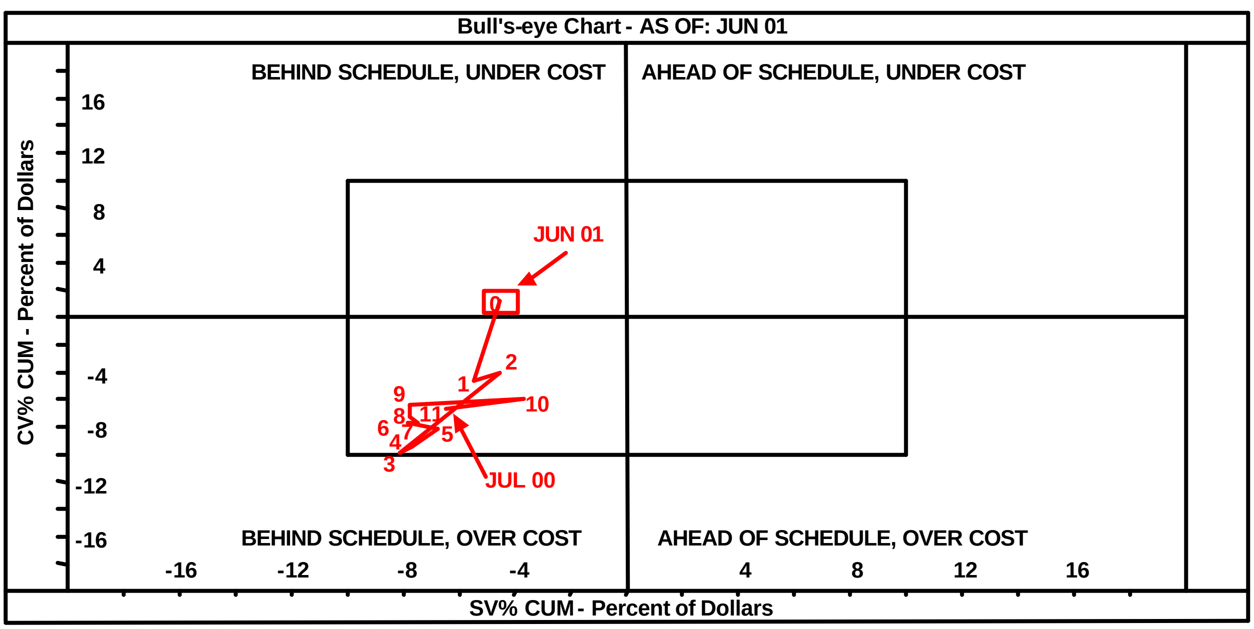
5. PERFORMANCE DATA

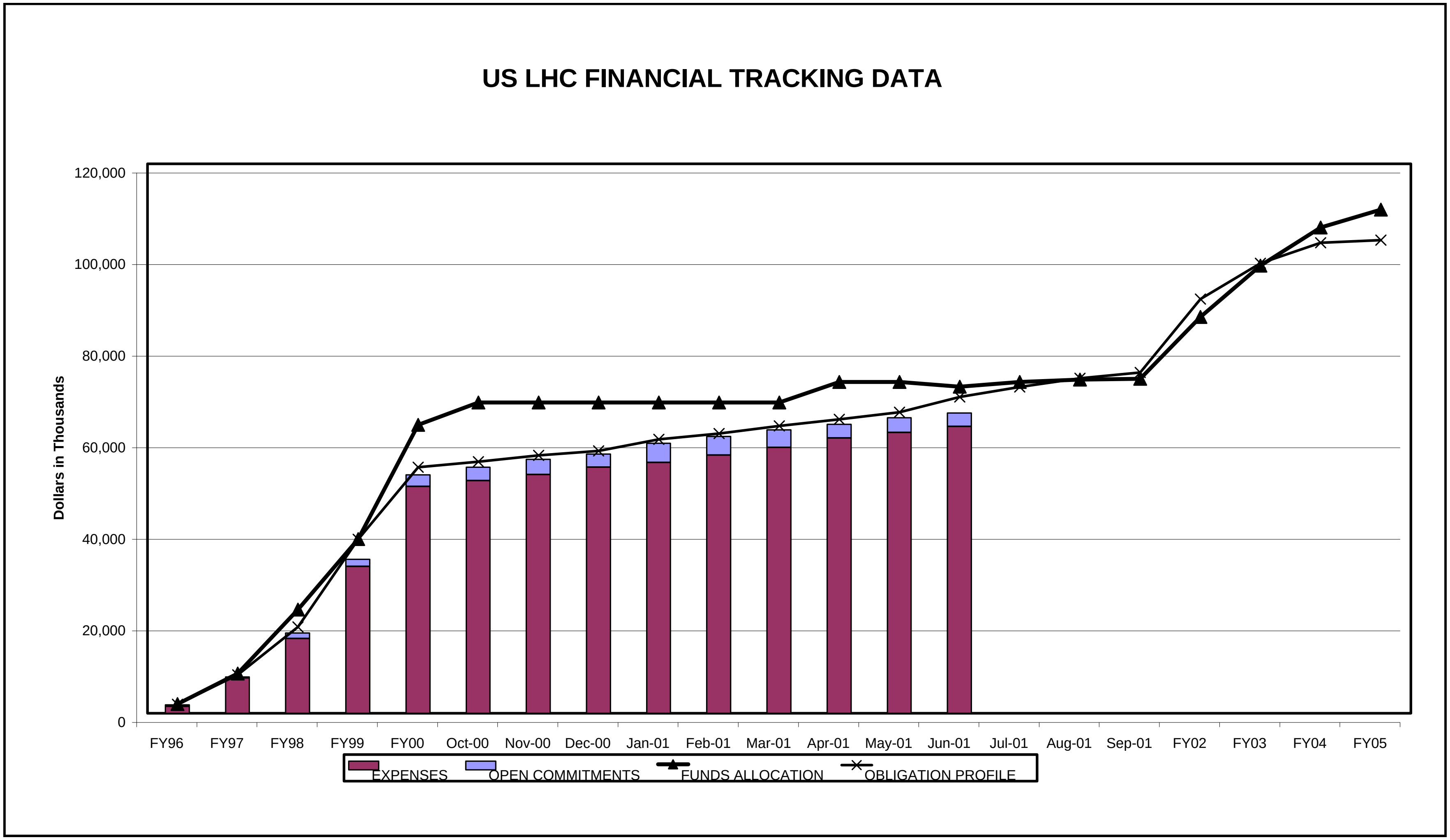
ITEM	CURRENT PERIOD					CUMULATIVE TO DATE					REPROGRAMMING ADJUSTMENTS		AT COMPLETION		
	BUDGETED COST		ACTUAL	VARIANCE		BUDGETED COST		ACTUAL	VARIANCE						
	WORK SCHEDULED	WORK PERFORMED	COST WORK PERFORMED	SCHEDULE	COST	WORK SCHEDULED	WORK PERFORMED	COST WORK PERFORMED	SCHEDULE	COST	COST VARIANCE	BUDGET	BUDGETED	ESTIMATED	VARIANCE
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
a. ORGANIZATIONAL CATEGORY															
BNL - 2	2,600.2	4,913.3	1,591.4	2,313.1	3,321.9	28,360.7	27,828.1	27,588.7	-532.6	239.4			45,131.8	45,131.8	0.0
FNAL - 2	4,168.3	4,457.8	1,084.2	289.5	3,373.7	28,433.2	28,593.9	28,312.9	160.8	281.0			40,562.9	40,562.9	0.0
LBNL - 2	948.6	251.2	561.3	-697.4	-310.2	13,057.2	10,278.4	10,032.7	-2,778.7	245.7			17,500.9	17,768.3	-267.4
OV - OVERHEAD 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0
b. COST OF MONEY 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0
c. GENERAL & ADMINISTRATIVE 2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0			0.0	0.0	0.0
d. UNDISTRIBUTED BUDGET 2													0.0	0.0	0.0
e. SUBTOTAL *(Performance Measurement Baseline)*	7,717.1	9,622.3	3,236.9	1,905.2	6,385.4	69,851.0	66,700.4	65,934.3	-3,150.5	766.1	0.0	0.0	103,195.7	103,463.0	-267.3
f. MANAGEMENT RESERVE 2												0.0	0.0		
g. TOTAL	7,717.1	9,622.3	3,236.9	1,905.2	6,385.4	69,851.0	66,700.4	65,934.3	-3,150.5	766.1	0.0	0.0	103,195.7		

COST/SCHEDULE PERFORMANCE CHARTS



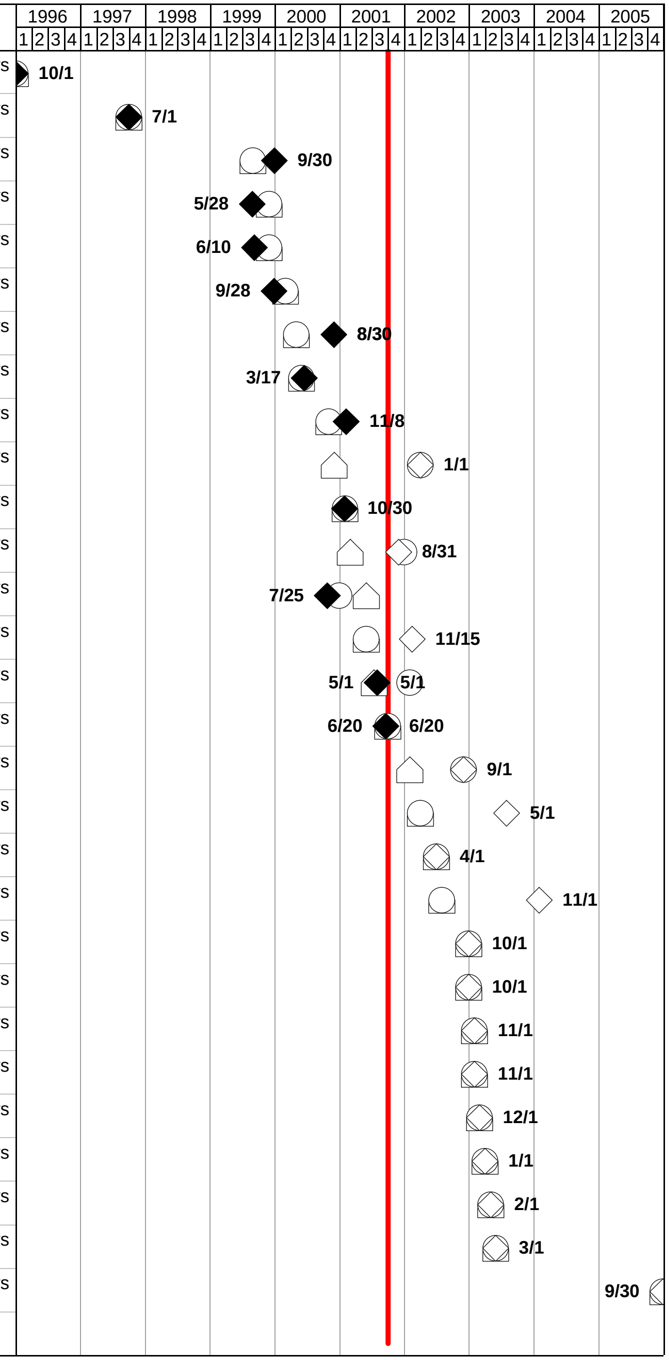






	FY96	FY97	FY98	FY99	FY00	Oct-00	Nov-00	Dec-00	Jan-01	Feb-01	Mar-01	Apr-01	May-01	Jun-01	Jul-01	Aug-01	Sep-01	FY02	FY03	FY04	FY05
INCREMENTAL																					
FUNDS ALLOCATION	2,000	6,670	14,000	15,400	24,917	4,900	0	0	-11	0	0	4,473	0	-1,000	1,000	500	200	13,500	11,200	8,330	3,921
OBLIGATION PROFILE	1,962	6,427	10,466	19,155	15,714	1,222	1,384	944	2,537	1,294	1,644	1,437	1,570	3,314	2,210	1,880	1,283	16,011	7,828	4,494	580
EXPENSES	1,515	6,186	8,594	15,755	17,498	1,248	1,356	1,606	994	1,610	1,703	2,057	1,225	1,291							
OPEN COMMITMENTS	296	-43	964	366	965	372	377	-436	1,336	-74	-267	-847	168	-248							
CUMULATIVE																					
FUNDS ALLOCATION	2,000	8,670	22,670	38,070	62,987	67,887	67,887	67,887	67,876	67,876	67,876	72,349	72,349	71,349	72,349	72,849	73,049	86,549	97,749	106,079	110,000
OBLIGATION PROFILE	1,962	8,390	18,856	38,011	53,725	54,947	56,331	57,275	59,812	61,105	62,750	64,187	65,758	69,071	71,282	73,162	74,445	90,456	98,284	102,778	103,357
EXPENSES	1,515	7,701	16,296	32,051	49,549	50,797	52,153	53,758	54,752	56,362	58,065	60,123	61,348	62,639							
OPEN COMMITMENTS	296	253	1,217	1,582	2,547	2,919	3,296	2,860	4,196	4,122	3,856	3,008	3,176	2,928							

ID	Milestone	Original	Revised	Forecast	Actual	Variance
	Project Start (10/1/95)	10/1/95	10/1/95	10/1/95	10/1/95	0 days
IR	Begin 1st Inner Triplet Quadrupole Model Magnet	7/1/97	7/1/97	7/1/97	7/1/97	0 days
SC	Complete Superconductor Test Facility Upgrades	6/1/99	6/1/99	9/30/99	9/30/99	87 days
SC	All Cable Production Support Equipment Delivered to CERN	9/1/99	9/1/99	5/28/99	5/28/99	-68 days
RF	Begin Assembly of 1st Dipole Model Magnet	9/1/99	9/1/99	6/10/99	6/10/99	-59 days
IR	Complete Inner Triplet Quadrupole Model Magnet Program Phase 1	12/1/99	12/1/99	9/28/99	9/28/99	-46 days
IR	Place Purchase Order for HTS Power Leads	2/1/00	2/1/00	8/30/00	8/30/00	151 days
IR	Complete Inner Triplet Quadrupole Model Magnet Program Phase 2	3/1/00	3/1/00	3/17/00	3/17/00	12 days
RF	Complete Dipole Model Magnet Program	8/1/00	8/1/00	11/8/00	11/8/00	71 days
RF	Begin RF Region Dipole Production Assembly	9/1/00	1/1/02	1/1/02	NA	0 days
IR	Begin Absorber Fabrication	11/1/00	11/1/00	10/30/00	10/30/00	-2 days
IR	Complete Inner Triplet Quadrupole Prototype Magnet Program	12/1/00	10/1/01	8/31/01	NA	-21 days
IR	Begin Interaction Region Beam Separation Dipole Prod. Assembly	3/1/01	10/1/00	7/25/00	7/25/00	-49 days
IR	Begin Inner Triplet Feedbox Fabrication	3/1/01	3/1/01	11/15/01	NA	185 days
IR	Begin Inner Triplet Quadrupole Production Assembly	4/15/01	11/1/01	5/1/01	5/1/01	-132 days
	Decision on RF Region Quadrupoles	7/1/01	7/1/01	6/20/01	6/20/01	-8 days
IR	Complete 1st Inner Triplet Quadrupole Magnet	11/1/01	9/1/02	9/1/02	NA	0 days
RF	Delivery of D3, D4 for IR4 right	1/1/02	1/1/02	5/1/03	NA	347 days
IR	Delivery of D2 for IR8 Left	4/1/02	4/1/02	4/1/02	NA	0 days
IR	Complete Inner Triplet Feedbox Fabrication	5/1/02	5/1/02	11/1/03	NA	393 days
IR	Delivery of All Inner Triplet System Components for IR8 Left (MQX, DFBX, D1)	10/1/02	10/1/02	10/1/02	NA	0 days
RF	Complete RF Region Dipole Production Assembly	10/1/02	10/1/02	10/1/02	NA	0 days
IR	Delivery of D2 for IR5 Left	11/1/02	11/1/02	11/1/02	NA	0 days
RF	Delivery of D3, D4 for IR4 left	11/1/02	11/1/02	11/1/02	NA	0 days
IR	Complete Absorber Fabrication	12/1/02	12/1/02	12/1/02	NA	0 days
IR	Delivery of All Inner Triplet System Components for IR8 Right (MQX, DFBX, D1)	1/1/03	1/1/03	1/1/03	NA	0 days
IR	Delivery of D2 for IR8 Right	2/1/03	2/1/03	2/1/03	NA	0 days
IR	Complete Interaction Region Dipole Production Assembly	3/1/03	3/1/03	3/1/03	NA	0 days
	Project Completion (9/30/05)	9/30/05	9/30/05	9/30/05	NA	0 days



Date: 8/21/01 Original Baseline Revised Baseline Forecast Actual